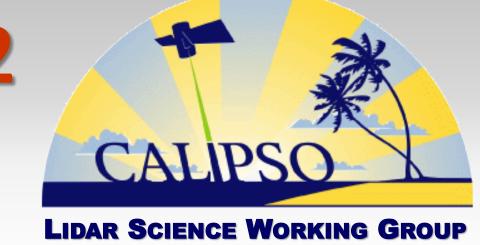
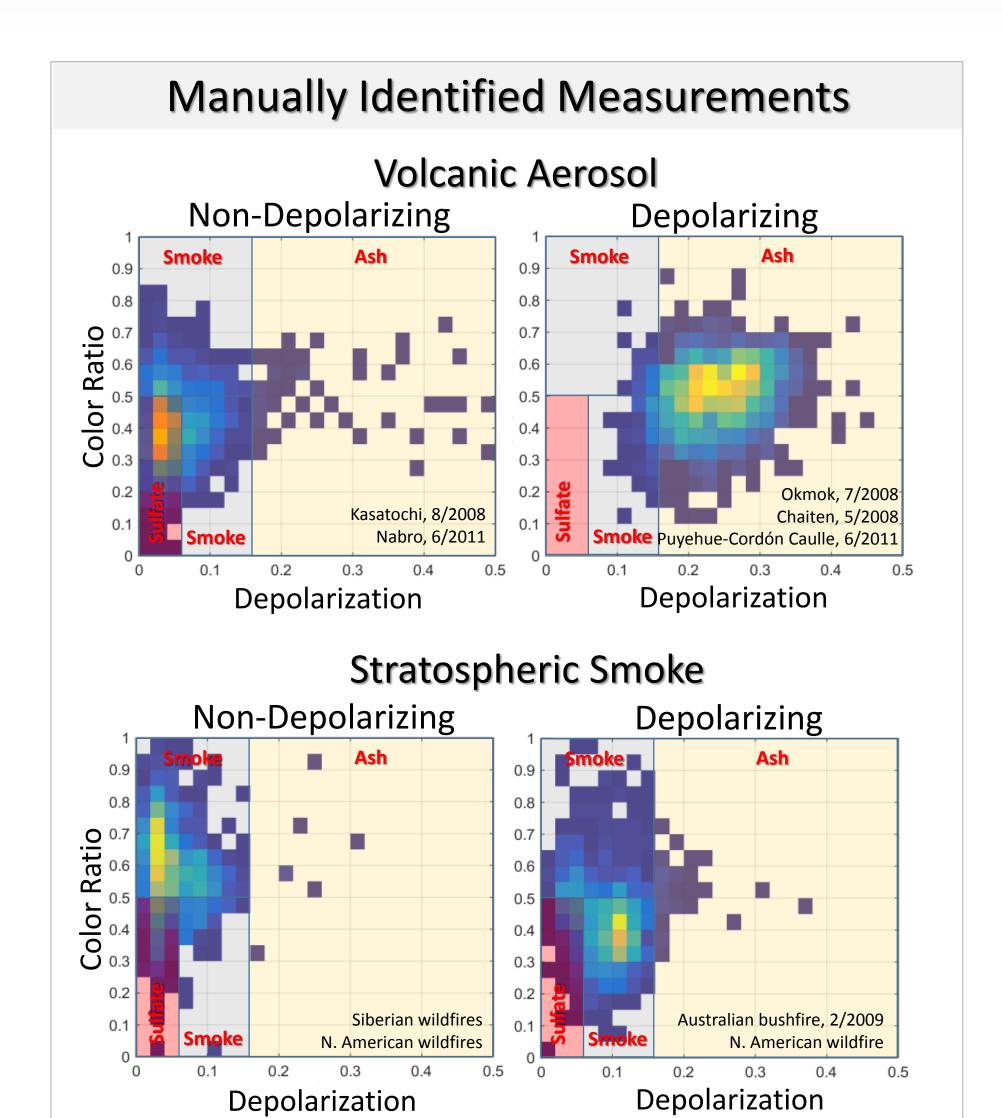
New Stratospheric Aerosol Subtypes Implemented in CALIOP Version 4 Level 2

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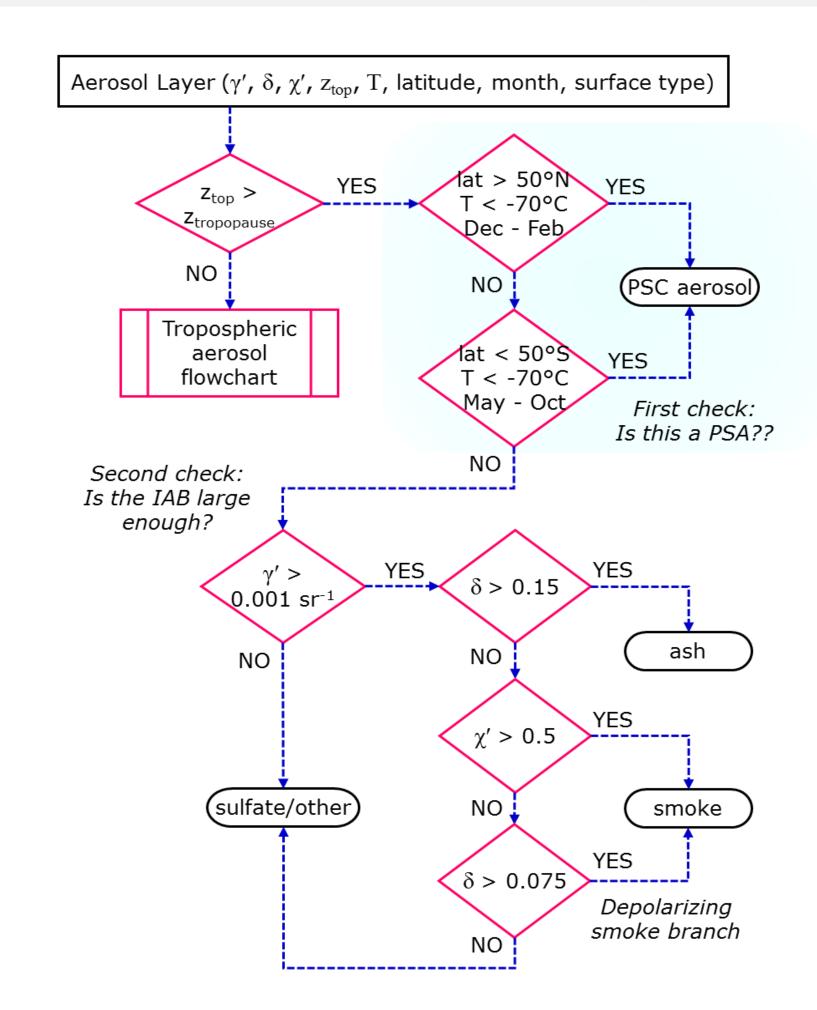
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Stratospheric aerosol subtypes determined by empirically derived thresholds based on manually identified volcanic, smoke and PSC aerosol events in the stratosphere.

V4 Stratospheric Aerosol Subtyping Flowchart



Classification of features above tropopause has changed with Version 4:

In Version 3, all features above the tropopause were classified as Stratospheric Features. In Version 4, these features can now be Cloud or Stratospheric Aerosol.

A new stratospheric aerosol subtyping algorithm is implemented in V4 to identify aerosol commonly found above the tropopause as Volcanic Ash, Sulfate, Smoke and PSC Aerosol. Aerosol that is weakly scattering or cannot by typed by the algorithm are given the generic Sulfate/Other classification.

Volcanic Ash

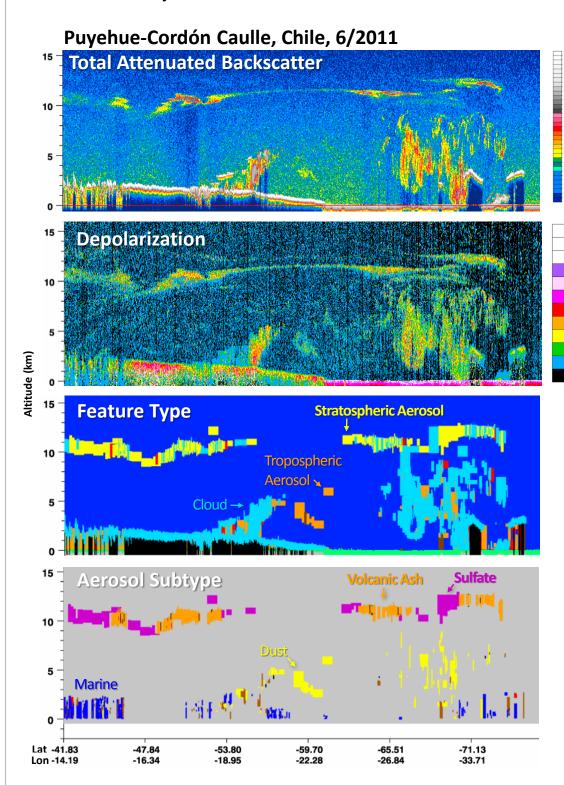
Identified by elevated depolarization ($\delta' > 0.15$) and enhanced backscattering ($\gamma' > 0.001~\text{sr}^{-1}$). Lidar ratio matches that of CALIOP dust based on Raman lidar retrievals of Eyjafjallajökull volcanic plume (Ansmann et al., 2010) and its similarity to Saharan dust lidar ratio retrievals from the same instrument.

Primary interpretation is non-depolarizing volcanic sulfate (δ' < 0.15).

However, any feature that is weakly scattering ($\gamma' < 0.001 \text{ sr}^{-1}$) or could not be

typed is given this classification. Lidar ratio matches that of CALIOP polluted

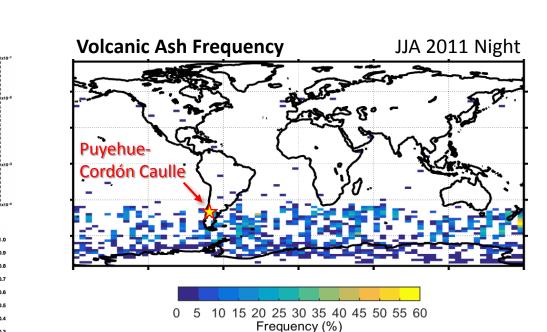
continental subtype, modeled as sulfate aerosol (Omar et al., 2009).



Sulfate/Other

Nabro Volcano, Eritrea, Africa, 6/2011

Total Attenuated Backscatter



 $S_{532} = 44 \text{ sr}$

Volcanic ash classification is only possible above the tropopause. Ash at lower altitudes will remain misclassified as cloud, dust or polluted dust because it is indistinguishable from these other types with CALIOP observables.

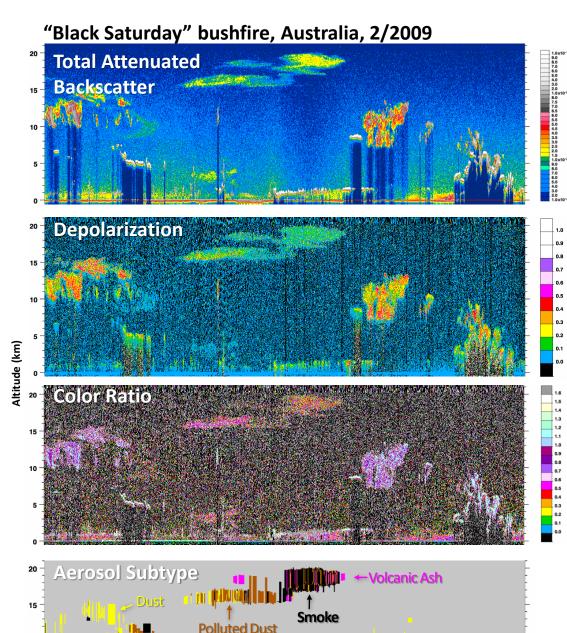
Ansmann et al. (2010), The 16 April 2010 major volcanic ash plume over centra Europe: EARLINET lidar and AERONET photometer observations at Leipzig and Munich, Germany, Geophys. Res. Lett., 37, L13810

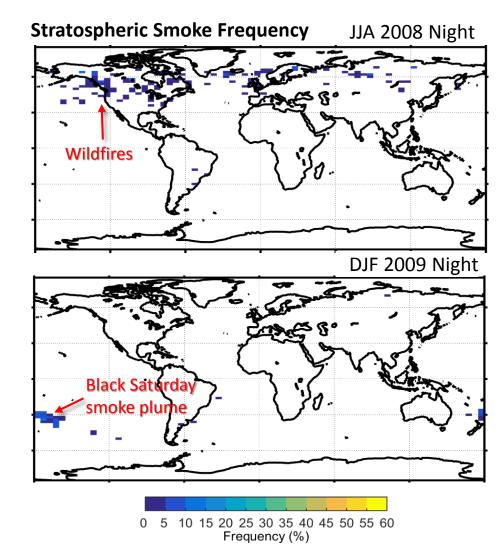
 $S_{532} = 70 \text{ sr}$

Elevated Smoke

 $S_{532} = 70 \text{ sr}$

Identified primarily by elevated color ratio ($\chi' > 0.5$). A "depolarizing smoke" branch is included for smoke plumes with elevated depolarization (0.075 < δ' < 0.15) and have χ' < 0.5. The "Black Saturday" bushfire in Australia is an example.





Smoke is rarely observed in the stratosphere.

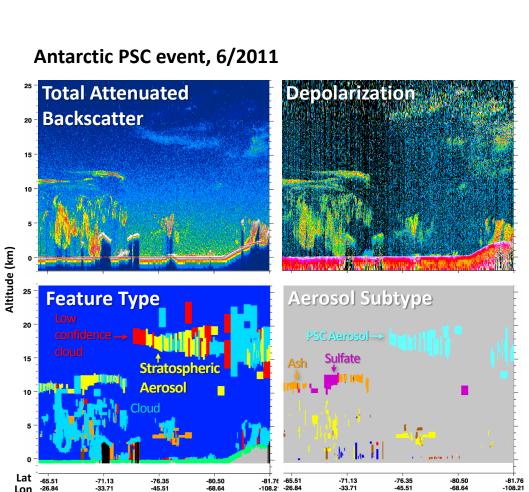
PSC Aerosol

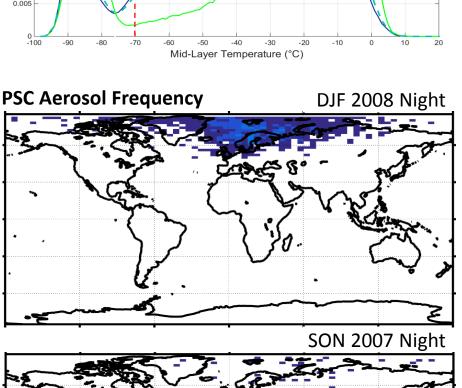
 $S_{532} = TBD$

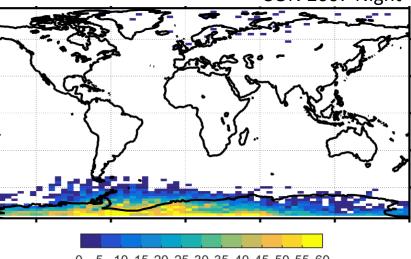
Aerosol related to polar stratospheric cloud events. Most analogous to supercooled liquid ternary solution, though fringes of PSCs are also given this classification. Required to exist in polar region in appropriate hemisphere during PSC season.

V4Test04Mod01 Layers Detected, June-September 2008, Latitude < 50°S

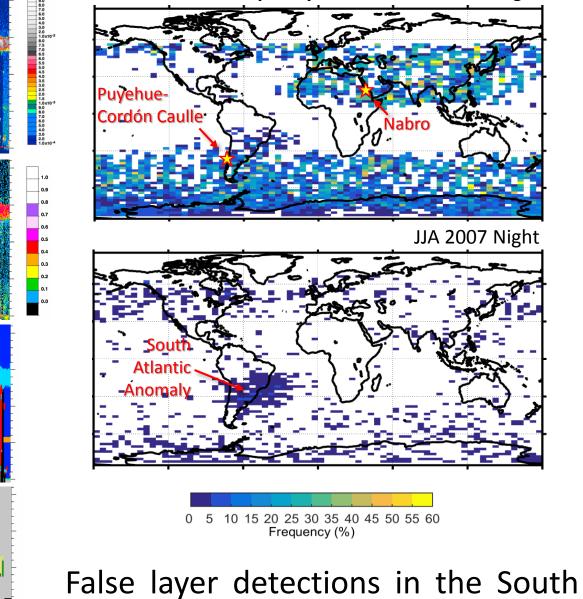
Mid-layer temperature threshold of T < 70°C based on layers detected by CALIOP during 2008 Antarctic PSC season.







0 5 10 15 20 25 30 35 40 45 50 55 60 Frequency (%)



False layer detections in the South Atlantic Anomaly are classified as Sulfate/Other.